

The study applies a reliable approach for satisfaction measurement based on 2 strong points. It uses elements from MCDMT, namely for calculating weighting coefficients. It fulfills requirements of standards for quality management systems.

ISO 9000 series is the most established worldwide set of standards for quality management systems. These standards require customer satisfaction measurement without specifying a particular approach.

As soon as the quality of the product (service) is always characterised by multiple criteria it is necessary to apply the methods for multiple criteria optimisation in order to achieve optimal quality of the product (service).

Learning is a very specific process; however the principles for quality management are applied to it. It is necessary to consider the specific features of the educational service (Nacheva-Skopalik L., 2011), (Nacheva-Skopalik L., 2007).

Multiple Criteria Decision-making Theory

Multiple Criteria Decision-making Theory (MCDMT) allows researchers to study how issues relating to human judgement and decision-making under uncertainty can be measured (Nacheva-Skopalik 2007). In the optimization theory it is accepted to refer to the quality characteristics of a product (service) as a set of objective variables $y=(y_1, y_2, \dots, y_m)$. Each of these parameters has a different importance.

There are a lot of optimization methods (Stoyanov, 1993). For these methods the choice of compromise optimal solution strongly depends on the importance of the objective variables (quality characteristics) expressed by the accepted weighting coefficients W_j for them. For this reason defining the importance by calculating of weighting coefficients is an essential stage in the multiple criteria decision making theory. The compromise solution can be moved to direction to the more important variables. This principle is particularly suitable to apply for optimal quality control. These weighting coefficients affect also the level of customer satisfaction with a product.

Calculation of weighting coefficients (ranking) by arranging the objective variables

There are no strictly formalized methods to define the importance (rank) of the quality characteristics and their corresponding weighting coefficients. A main problem to overcome is that the opinion for the importance of the quality characteristics is subjective perception. Therefore relatively reliable weighting coefficients are defined applying approaches from the subjective statistics to objectively evaluate subjective customers' opinions. Customers' opinions are normally collected by enquiry.

One reliable method for defining weighting coefficients by customers' (experts') opinions which uses rank correlation method (Kendal, 1957) is developed (Stoyanov, 1993; Nacheva-Skopalik, Stoyanov & Skopalik, 2004;). A number of customers R are asked to give their opinion about the importance of all product quality characteristics y_j . The number of the quality characteristics is m . Customers fill an inquiry card arranging the quality characteristics with numbers from 1 to m . It is recommended that the objective variables be presented in a random sequence without numbering. Customers are allowed to put the same rank for more than one characteristic.

The weighting coefficients for the characteristics are calculated only if there is concordance in the customers' opinions.

The concordance in the customers' opinions is checked by calculating the concordance coefficient W_k using the rank correlation methods (Kendal, 1957). The concordance coefficient can change from 0 in case of full lack of concordance in the opinions to +1 in case of full concordance in the opinions. The significance of the calculated concordance coefficient W_k is evaluated using defined criteria and table values. If the calculated values are bigger that

the table values for the relevant degrees of freedom and accepted probability, the conclusion is that with the chosen probability W_k is a significant concordance coefficient, i.e. there is concordance between the customers' subjective opinions, and the weighting coefficients are calculated (Stoyanov, 1993). It is obvious that the calculated weighting coefficients are more reliable for bigger value of probability.

A particular strength of the approach is that considering the concordance coefficient, the number of customers R and the number of the quality characteristics m, it gives reliable results for the weighting coefficients with chosen probability even for a small number of enquired customers, unlike the standard statistical approaches which use a very big number of data. Furthermore, it is applicable for various products, including health and medical area (Stotanov S., 2008).

AN APPROACH FOR SATISFACTION MEASUREMENT

Customer satisfaction with the quality of products and services is very subjective perception hence it is necessary to find a reliable approach to evaluate it for each individual customer. At the same time the process of continual quality improvement requires to have general evaluation for the level of satisfaction of all customers with particular product. In order to achieve this evaluation it is necessary to apply suitable and reliable approach to objectively evaluate subjective individual opinions and techniques used in the subjective statistics.

For the purpose of evaluation of customers' satisfaction each quality characteristic can be characterized by quantitative and qualitative valuations. The qualitative valuation defines the level of importance of the quality characteristic. The quantitative valuation gives the level of customer satisfaction with this quality characteristic. The combination of these two valuations gives a complex evaluation of the customer's satisfaction with the chosen quality characteristic (Nacheva-Skopalik, 2007).

The developed approach for satisfaction measurement applies the method for calculating weighting coefficients to define the importance of the characteristics (qualitative valuation).

The approach applies a numerical valuation of the level of customer's satisfaction with each characteristic as quantitative valuation. This quantitative valuation uses previously defined scale. A scale with values between 0 and 10 or values between 0 and 100 are often used. The value 0 means full no satisfaction, the value 10 (100) means full satisfaction. All customers' opinions, processed in a suitable way, give the general value for all customers.

The developed approach for satisfaction measurement successfully combines proven approaches from MCDMT and requirements of standards for quality management systems.

Graphical presentation of satisfaction measurement results

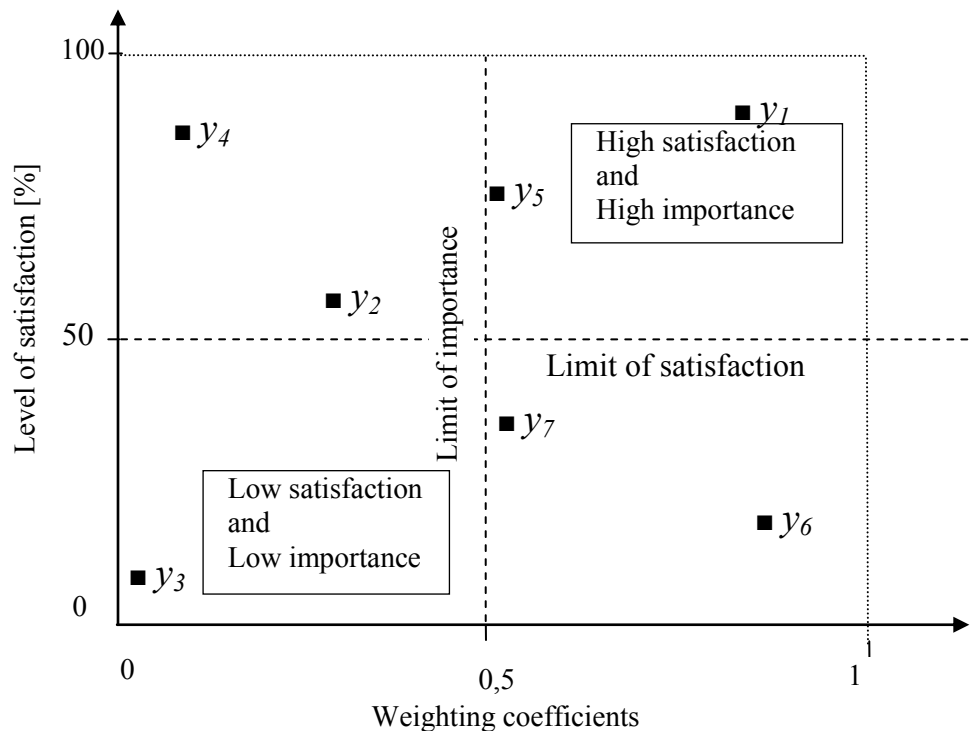
The graphical presentation of satisfaction measurement results is shown in supplementary Figure 1. The weighting coefficients are projected on the x-axis and the level of customers' satisfaction with each characteristic (given in %) is projected on the y-axis.

For deeper analysis of the results it is recommended to accept limit of satisfaction. For the different cases this limit can be different. For the example from the figure the limit of satisfaction is accepted 50%. The accepted limit of satisfaction defines the areas with low and high satisfaction. The chosen limit for the areas of low and high importance depends on the number of the chosen quality characteristics and the values of the weighting coefficients. For bigger number of characteristics the weighting coefficients will be with closer values.

The graphical presentation clearly visualizes the results and facilitates the process of their analysis and decision making. It is easy to trace at the same time what is the importance of each characteristic and what is the level of satisfaction with this characteristic.

Four areas in the space of the weighting coefficients and the level of satisfaction are defined:

- Area of high satisfaction and high importance (y_1);
- Area of low satisfaction and low importance (y_3);
- Area of low satisfaction and high importance (y_6);
- Area of high satisfaction and low importance (y_4).



Supplementary Figure 1. Customer satisfaction with product quality characteristics (Nacheva-Skopalik L., 2011)

The satisfaction measurement results and the position of each characteristic in the chart area are important information in the process of making relevant decisions and actions for optimal quality management. In order to increase customers' satisfaction the aim is to achieve satisfaction above the accepted limit. This is particularly important for the quality characteristics with high importance. The evaluation of customers' satisfaction provides conditions to find optimal control of the product quality that improves the characteristics with low satisfaction without worsening the characteristics with high level of satisfaction. At the same time a deep analysis is necessary for characteristics with low importance and low level of satisfaction. Considering the satisfaction measurement results is essential contribution to the process of making decisions for improving quality of a product; however the particular decision depends also on the particular product (service) and the production and market strategy of the company.

So called “decision maker” has the key role and importance in the process of optimal quality control and his/her expertise is crucial for finding the best solution. Decision maker

can be one person or a team of persons. The decision maker have to have excellent knowledge for the product or process to explore and to be expert at strategies and methods for multiple criteria optimization. He has to recommend or make optimal decision based on the analysis of various different solutions. Normal practice is to make the optimal decision after intensive consultations and negotiations between producers, customers, managers, and people with knowledge and experience in methods for satisfaction measurement.

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